# Energy from Organic Wastes:

## Technical and Project Considerations for Anaerobic Digestion

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## Presenters' Perspective

- California Situation
  - Regulations
  - CalRecycle is invested
  - Significant existing infrastructure
  - Highly urban
  - Large volume of disposed wastes
- Point of view of project developer
- Anticipate that listeners will have a broad range of technical understanding

# PART I

## California Regulations:

Motivation and Incentive
for Anaerobic Digestion

## Background, Motivating Factors

- High percentage of organics are being landfilled
- EPA has determined that landfills are a leading source of GHG emissions
- Valuable materials are being under-utilized

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- AB 1826 (2014) mandates **organic waste processing, either through separate collection and processing** or **mixed collection and processing**.
- AB 1594 (2014) **removes diversion credit** for using green waste for daily cover at landfills.

## Why AD?

- Satisfies regulatory requirements
- Produces valuable renewable energy
- Reduces landfill disposal
- Reduces Greenhouse Gas emissions
- Digestate has value as organic fertilizer
- Potential positive revenue generator under certain market conditions

## Complementary Actions

California Air Resources Board (ARB) and California Energy Commission (CEC) provide incentives for:

- Conversion of biogas to CNG
- Reduction of Greenhouse Gas emissions
- Production of electricity

## Complementary Actions

Relative value of CNG from biogas and converted to RNG vehicle fuel (CA):

| | |
|---|---|
| • Natural Gas market Price | $ 5.00 / mmBtu |
| • Renewable Fuel Standard (RINS) | $ 8.00 / mmBtu |
| • Low Carbon Fuel Standard (LCFS) | $ 4.00 / mmBtu |
| Total | $17.00 / mmBtu |

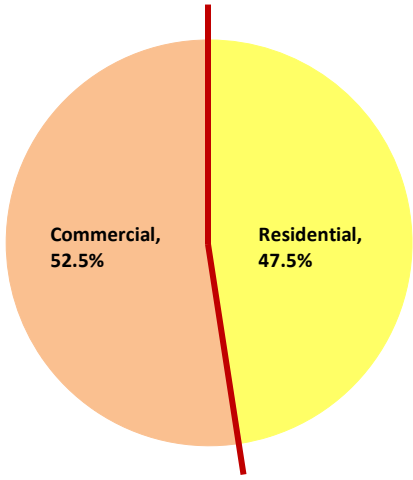
**Approximately = $2.13 / gasoline gallon equivalent**

# PART II

From Waste to Feedstock

# Disposed Waste Stream

Composition by Generator:




Waste Stream Composition - 2008 California Statewide Waste Characterization

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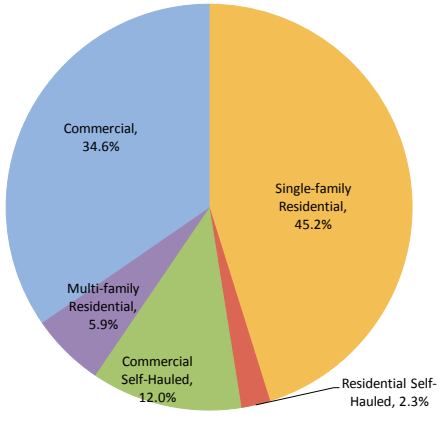


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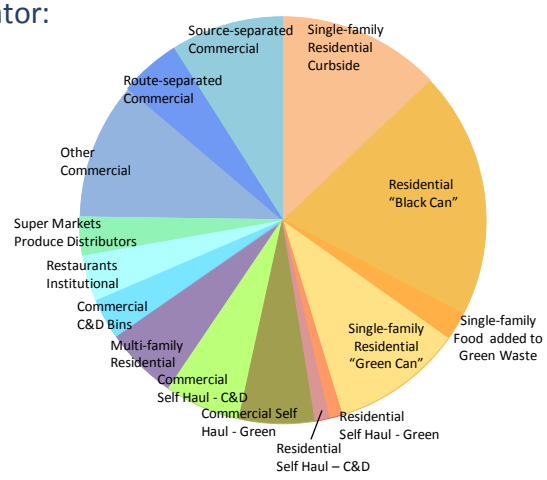
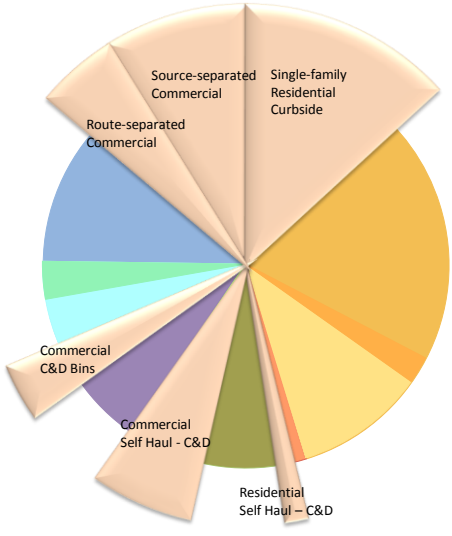


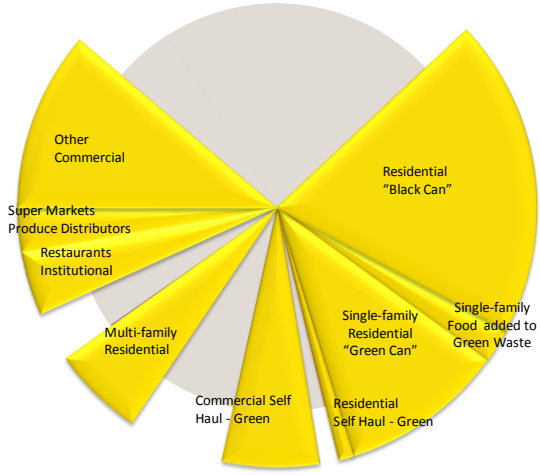

# Disposed Waste Stream

Portions with <u>low</u> Organic content



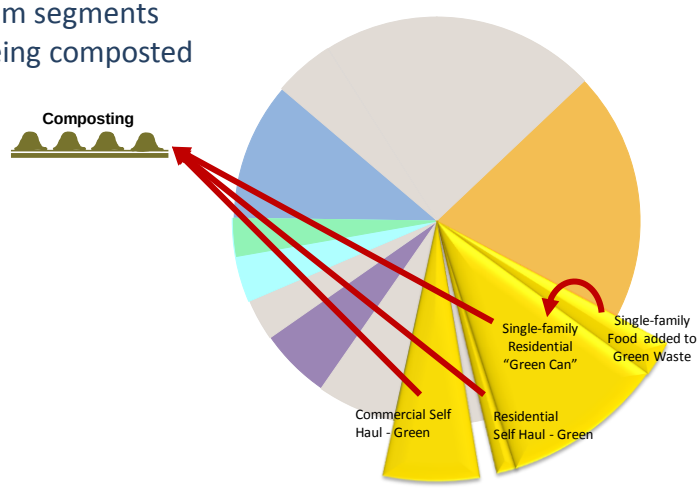
# Disposed Waste Stream

Remainder with high Compostable Organic content, typically higher than 25%.




# Disposed Waste Stream

Waste Stream segments currently being composted



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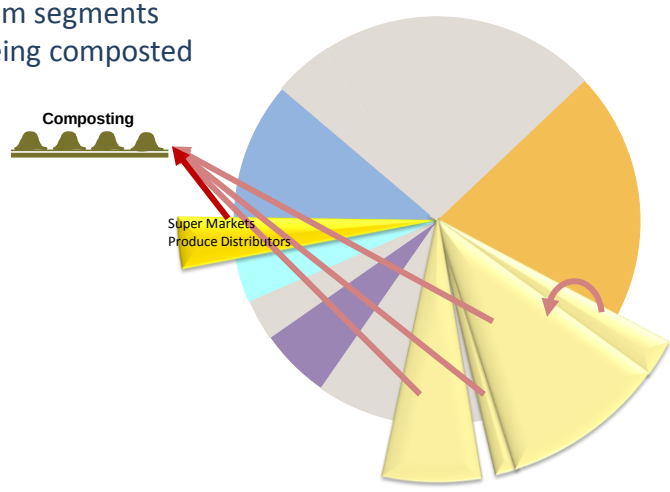
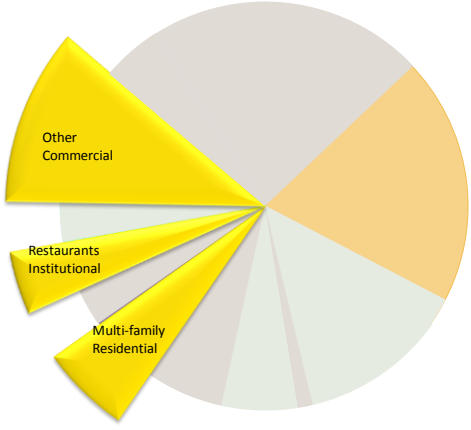



# Disposed Waste Stream

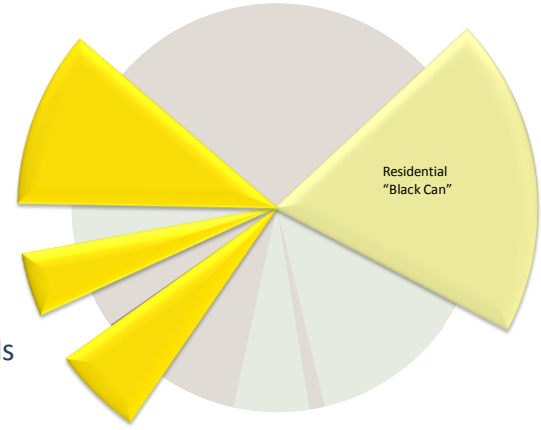
Remaining Commercial Waste Stream segments with high Organic content, suitable for **Anaerobic Digestion**



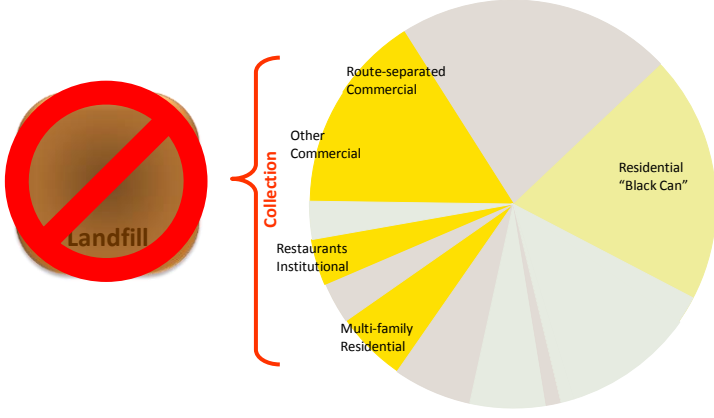
# Disposed Waste Stream

Remaining Commercial Waste Stream segments with high Organic content, suitable for **Anaerobic Digestion**

Residential "Black Can" Waste Stream also has high Organic content – but typically higher levels of contaminants




# From Collected Waste to AD Feedstock



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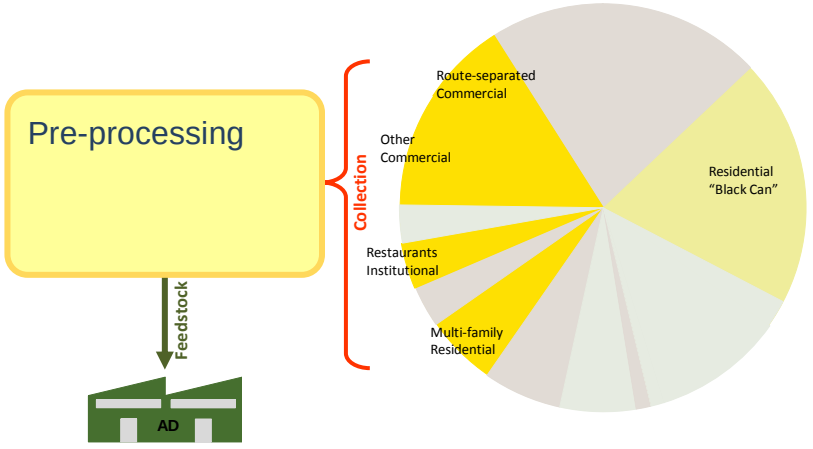


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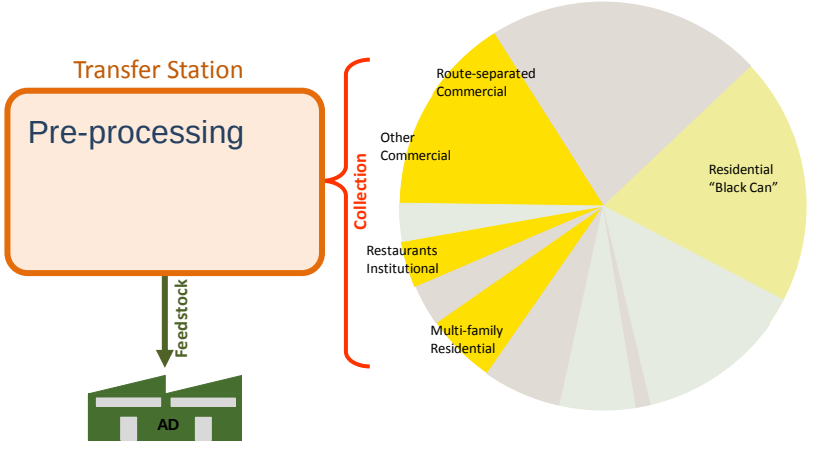

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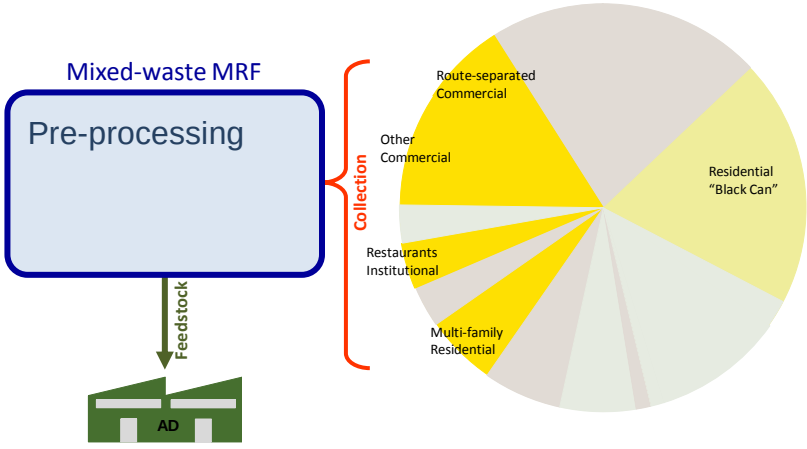


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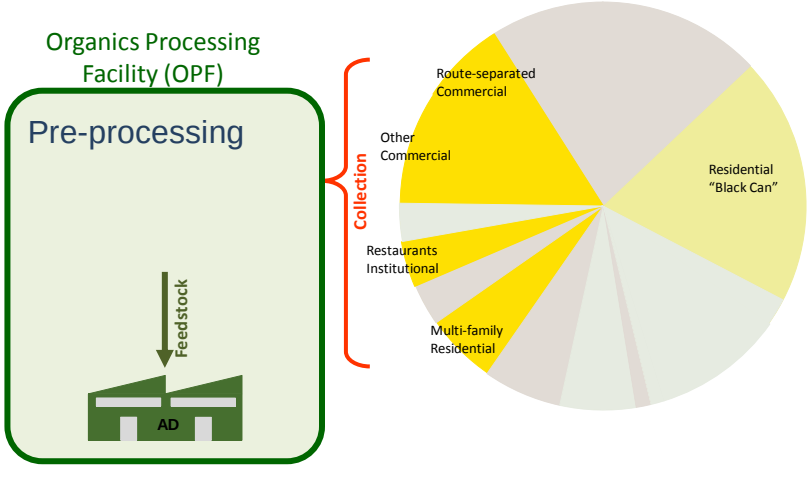

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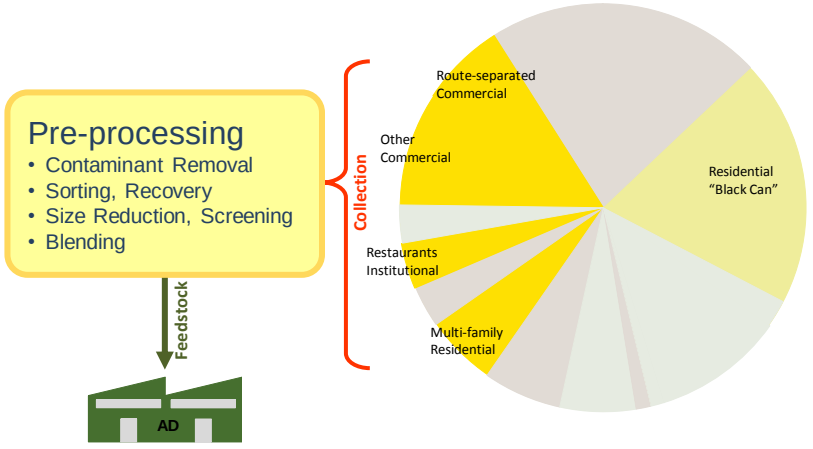
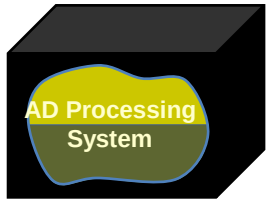



# PART III

## AD Systems

## AD Systems – Flow Diagram

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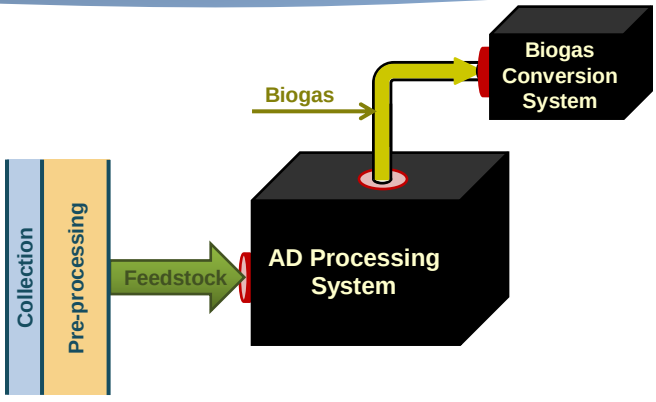

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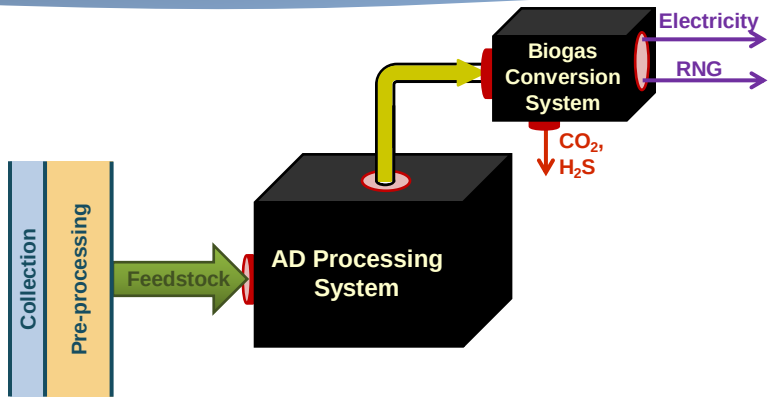


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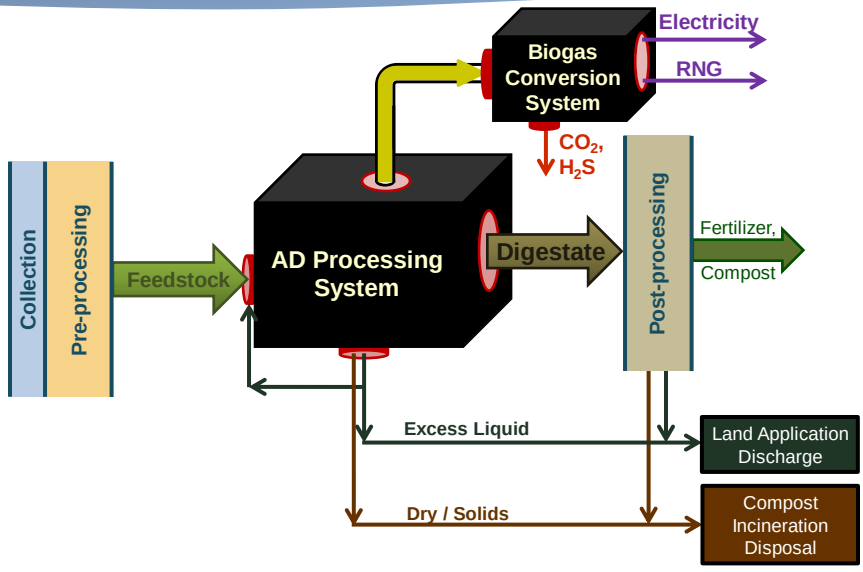
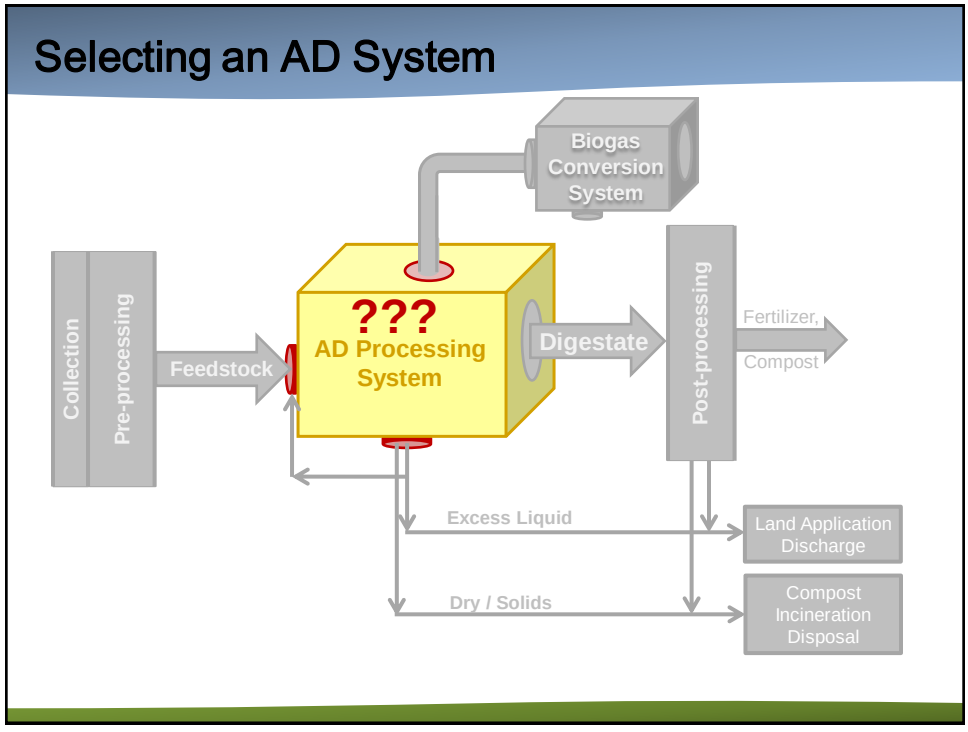
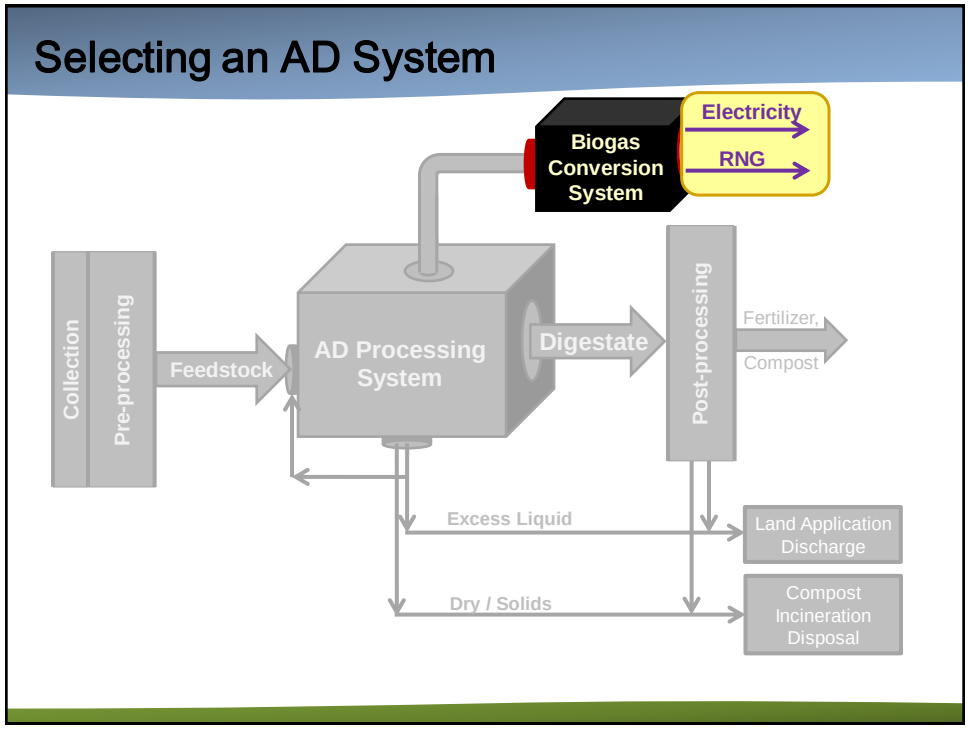



Selecting an AD System
Biogas Conversion System
???
AD Processing System
Collection
Pre-processing
Feedstock
Digestate
Post-processing
Fertilizer, Compost
Excess Liquid
Land Application Discharge
Dry / Solids
Compost Incineration Disposal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Biogas Conversion System
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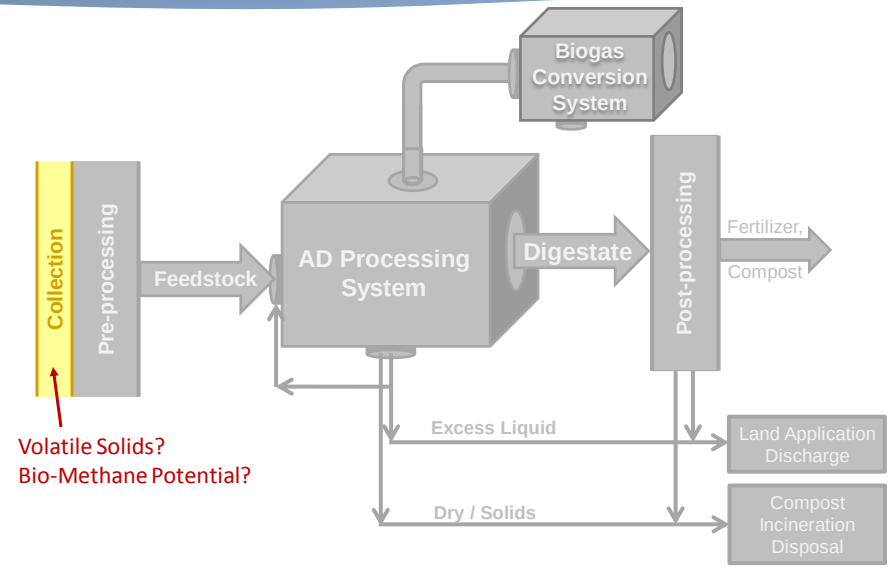
## Selecting an AD System

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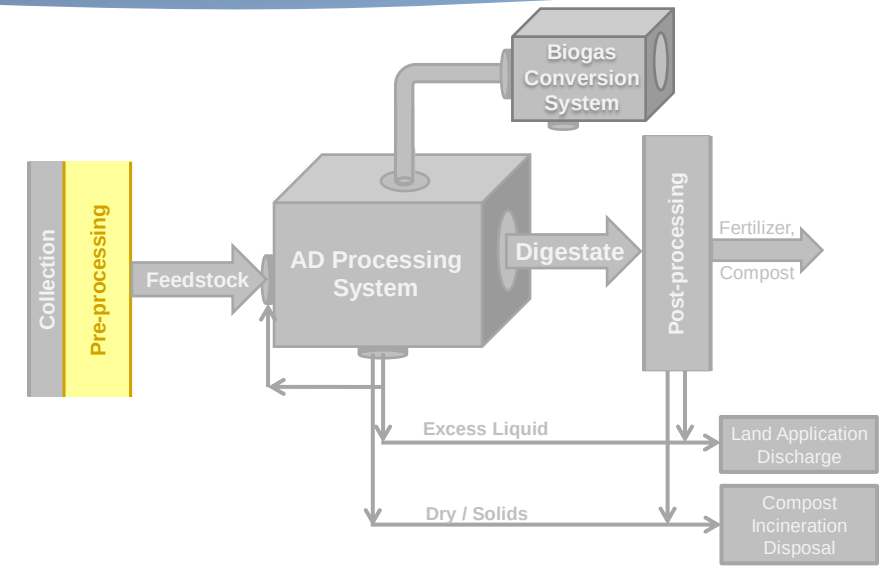

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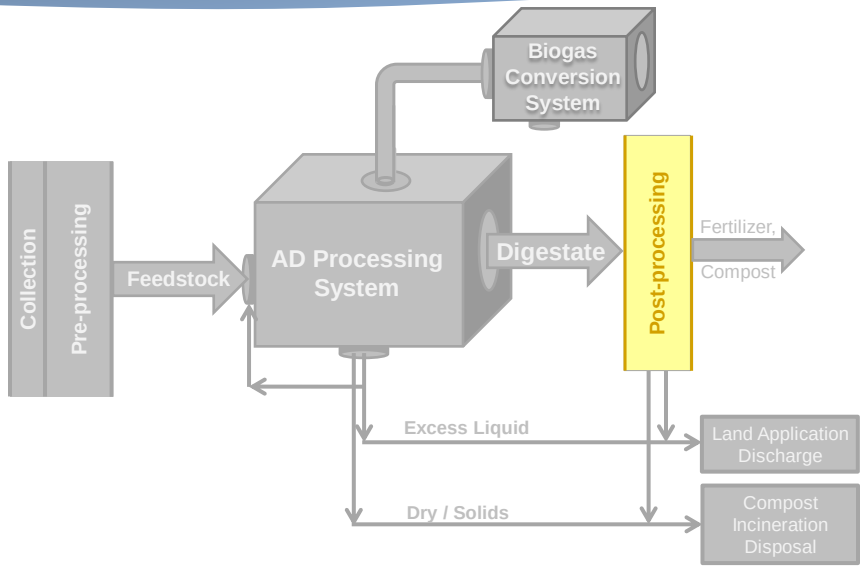



# PART IV

## Commercially Available Systems

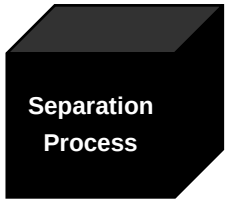
## Commercially-available AD Systems

1. Wet
2. Dry Fermentation
3. Horizontal Plug Flow
4. Vertical Plug Flow

## AD Systems – Wet

Low solids (< 10%)
Oldest technology

# AD Systems – Wet

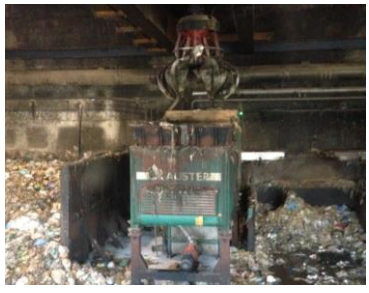



**Organics Press:**

**Wet/Dry Separation**
**De-packaging**

# AD Systems – Wet

## Organics Presses



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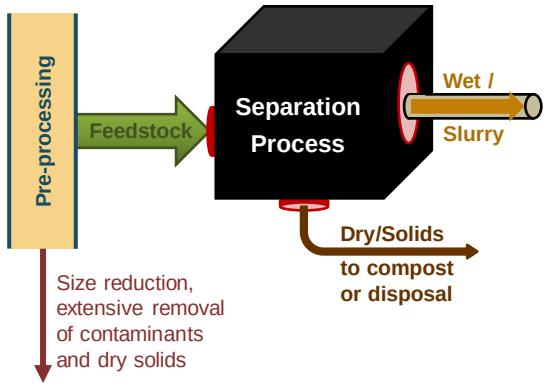


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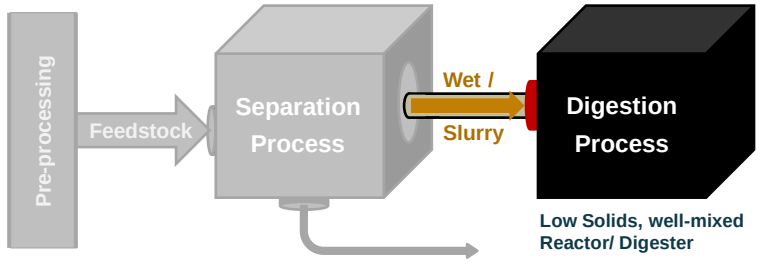
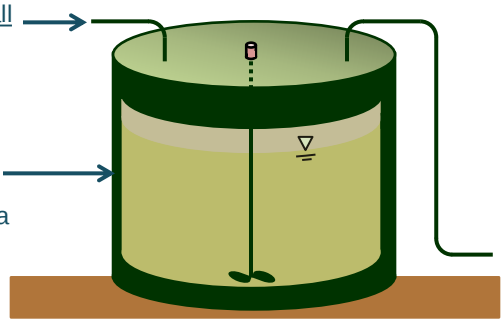


# AD Systems – Wet

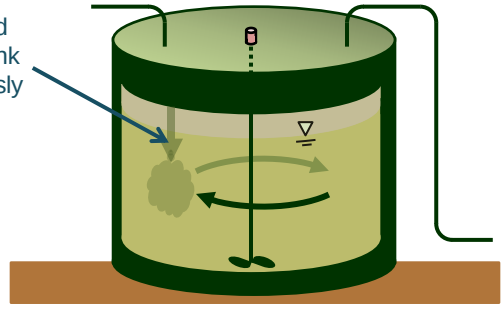
Slurry is piped into tank reactor. Small particle size is imperative.

Reactor tank contains large volume of liquid with active bacteria residing inside.



# AD Systems – Wet

Slurry is diluted and mixed in reactor tank which is continuously stirred.



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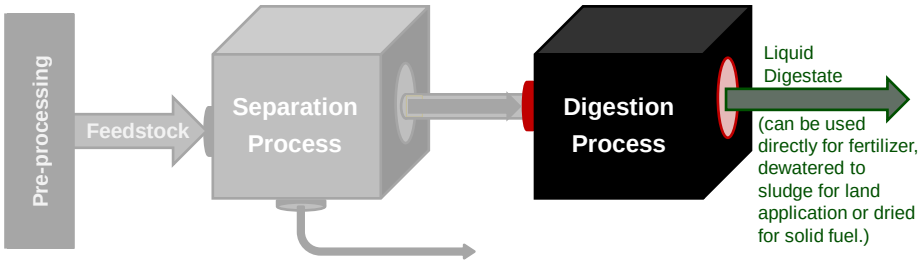


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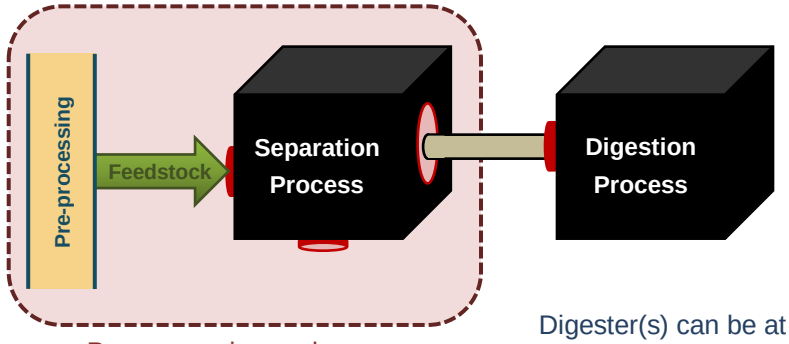
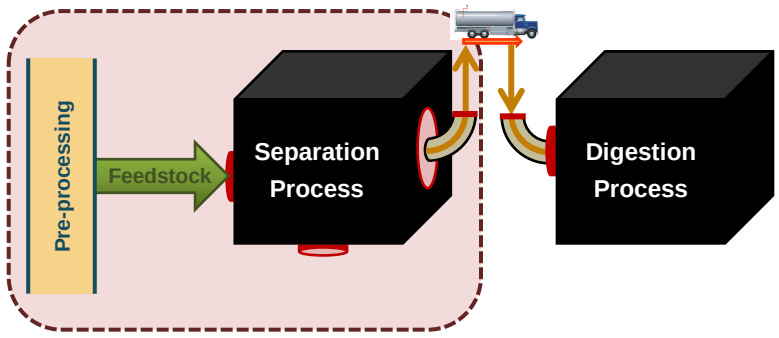



Pre-processing and separation can be performed in a MRF or TS

Digester(s) can be at a different location

## AD Systems – Wet

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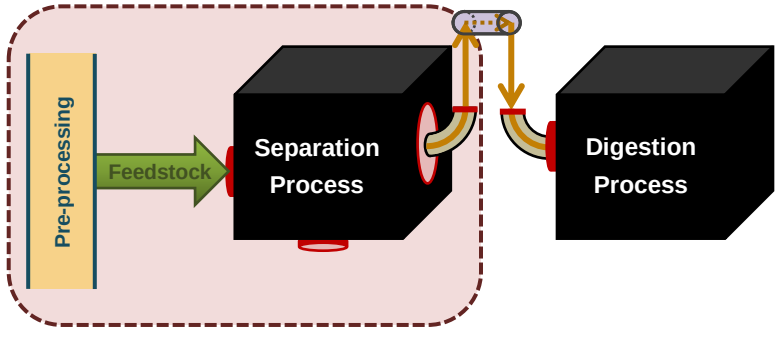

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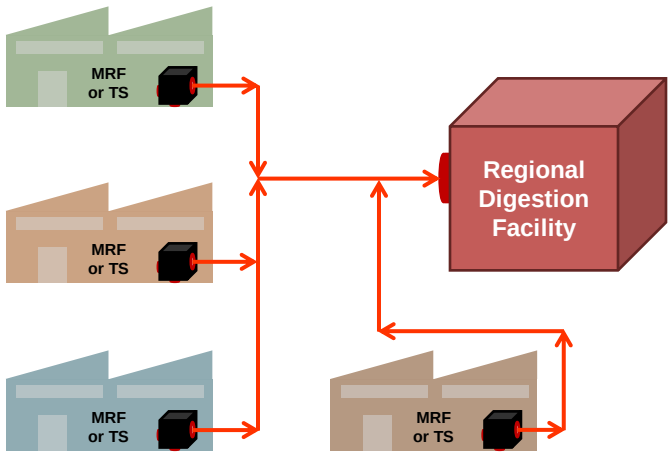


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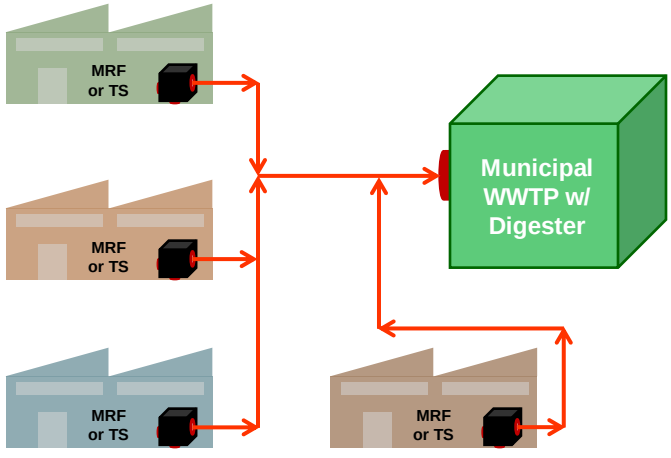

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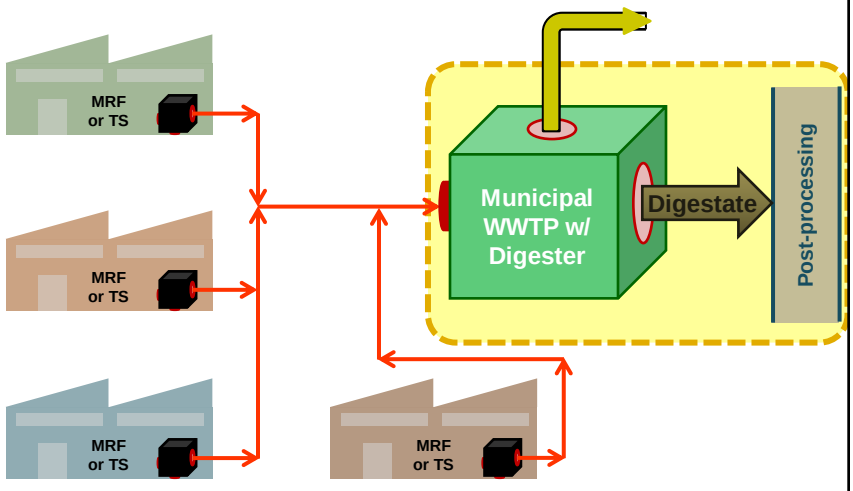


## AD Systems – Wet

Advantages:

1. Highest gas yield. Up to 15 mmbtu per ton of Volatile Solids digested depending upon Food Waste type
2. Well-known and time-tested technology, including digestate management
3. Can readily accept liquid wastes
4. Early removal of indigestible materials reduces digestate management effort
5. Possible use of municipal digester – reduces CapEx and OpEx for the solid waste manager

## AD Systems – Wet

Issues and challenges:

1. Relatively large footprint
2. Extensive pre-processing required
3. Contaminants may affect biological activity
4. Municipal Digester may be more sensitive to contaminants
5. Could have significant wastewater management, notably ammonia removal
6. Highest volume of rejects

## AD Systems – Dry Fermentation

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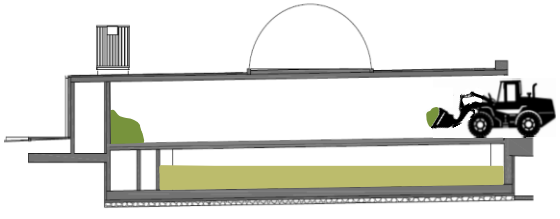
## AD Systems – Dry Fermentation

Feedstock is placed into digester with a loader



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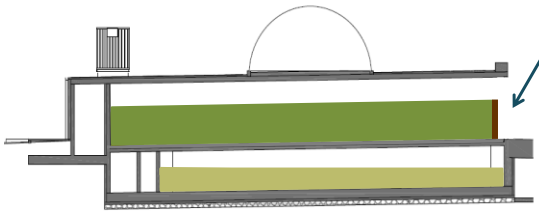


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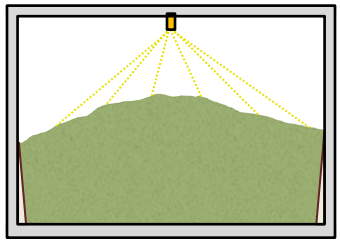
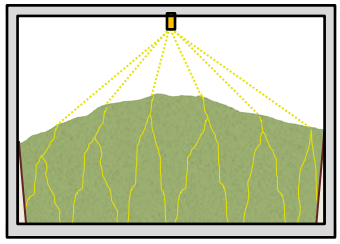


Percolate, containing active bacteria is sprayed onto feedstock through an overhead sprinkler system

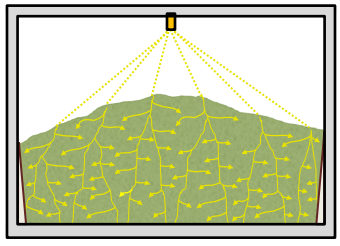
## AD Systems – Dry Fermentation



Materials are static throughout process.

Penetration of percolate into the pile of materials introduces bacteria to feedstock

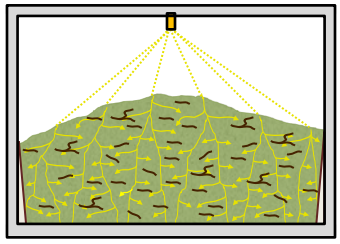
## AD Systems – Dry Fermentation



Thorough digestion requires percolate to reach all feedstock through complete saturation.

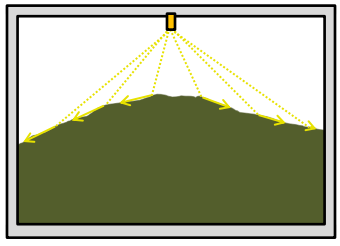
**Less saturation = less biogas yield = more odor.**

## AD Systems – Dry Fermentation



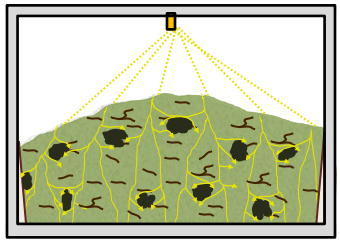
Variable material sizes increase porosity, facilitate saturation and improve bacteria introduction and biogas production.

## AD Systems – Dry Fermentation



Materials that are dense or of similar sizes can thatch or clump - decreasing porosity, limiting saturation and bacteria introduction, resulting in lower biogas production.

## AD Systems – Dry Fermentation



Local concentrations of thatched or clumped materials are likely, preventing full digestion in these zones, reducing biogas production and increasing odors.

## AD Systems – Dry Fermentation

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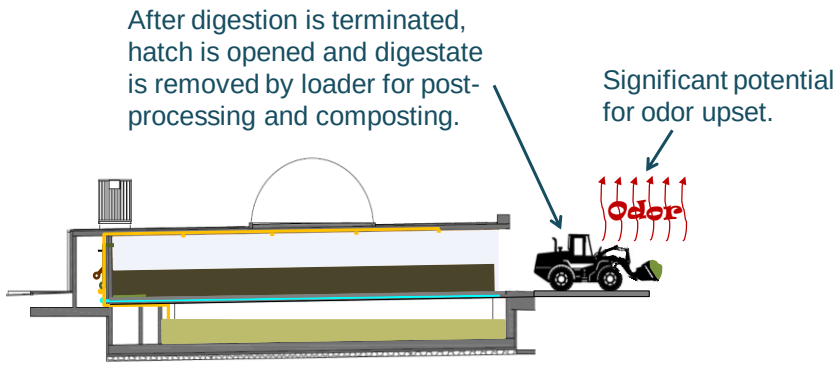



## AD Systems – Dry Fermentation

Advantages:

- Little or no pre-processing required, depending on the feedstock
- Wide range of feedstocks
- Can process very dry materials
- Digestate has high carbon content for good composting, but high level of contaminants
- Material movement is with loader, less piping to maintain
- Low energy usage

## AD Systems – Dry Fermentation

Issues and challenges:

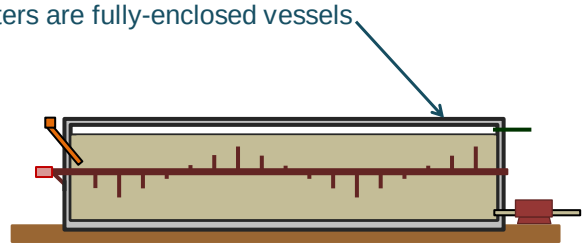
- Relatively low biogas yields: 4-8 mmbtu/ton of VS of organic wastes, depending on waste type
- Digestate can have more odor resulting from incomplete digestion
- Digestate must be transported by loader – management of odor more difficult - high potential for odor upset
- Limited ability to accept liquids

## AD Systems – Horizontal Plug Flow

## AD Systems – Horizontal Plug Flow

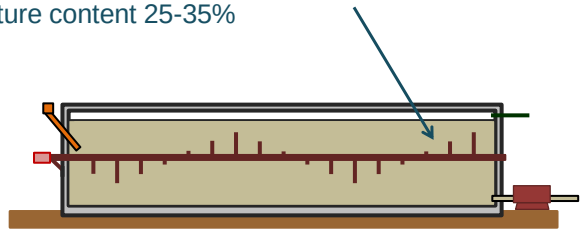
## AD Systems – Horizontal Plug Flow

Digesters are fully-enclosed vessels



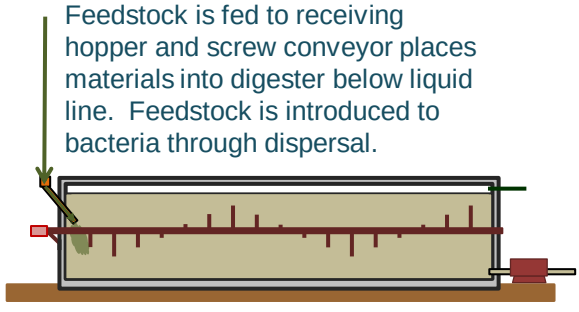
## AD Systems – Horizontal Plug Flow

Bacteria colony resides in digestate
Moisture content 25-35%



## AD Systems – Horizontal Plug Flow

Feedstock is fed to receiving hopper and screw conveyor places materials into digester below liquid line. Feedstock is introduced to bacteria through dispersal.



## AD Systems – Horizontal Plug Flow

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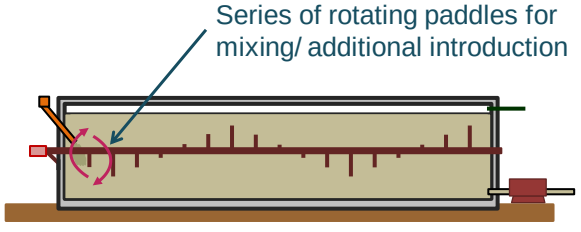
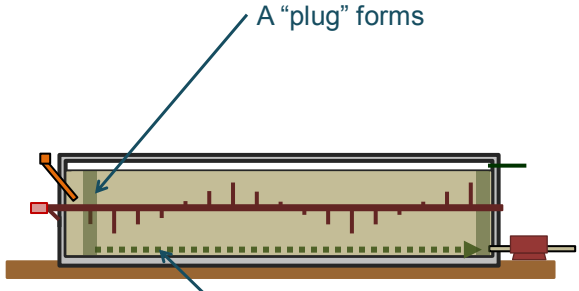


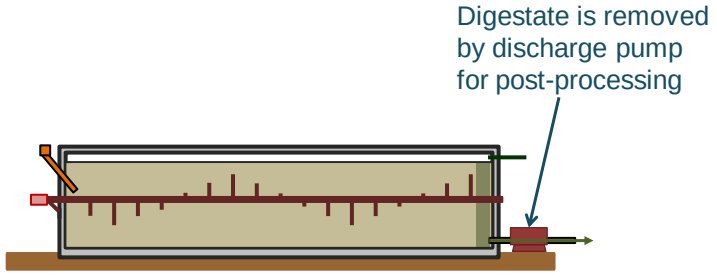
## AD Systems – Horizontal Plug Flow

Rotating paddles

## AD Systems – Horizontal Plug Flow

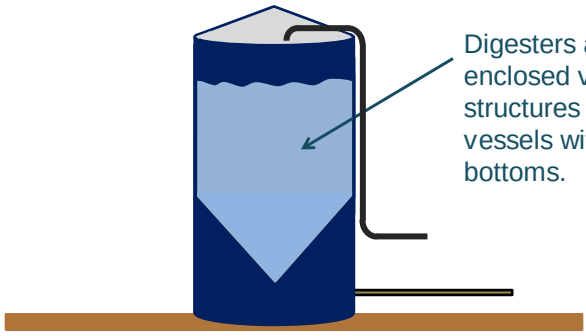


## AD Systems – Horizontal Plug Flow



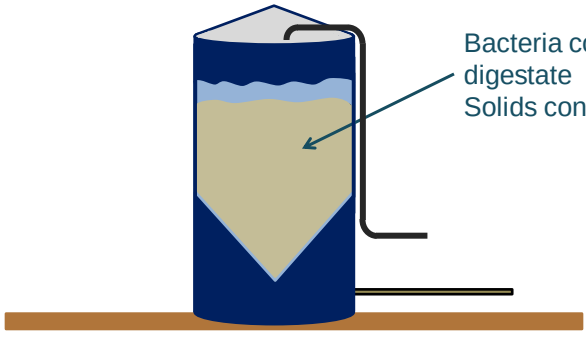

## AD Systems – Vertical Plug Flow

## AD Systems – Vertical Plug Flow



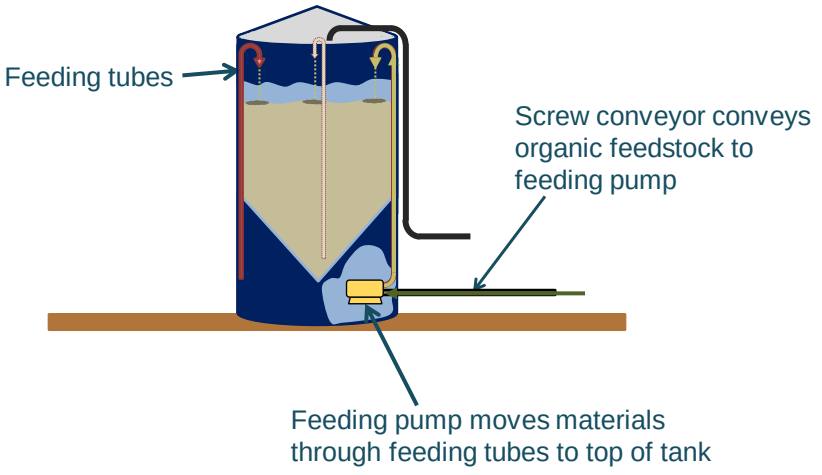
Digesters are fully-enclosed vertical tank structures with inner vessels with conical bottoms.

## AD Systems – Vertical Plug Flow

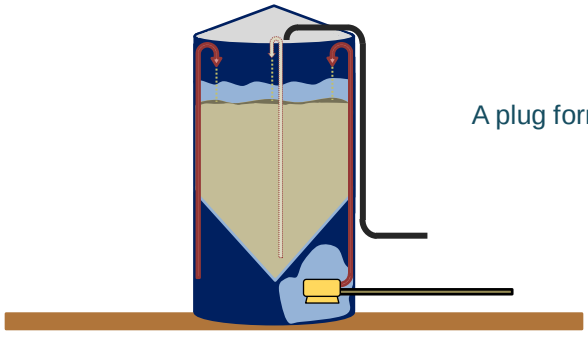


Bacteria colony resident in digestate
Solids content 25-35%

## AD Systems – Vertical Plug Flow

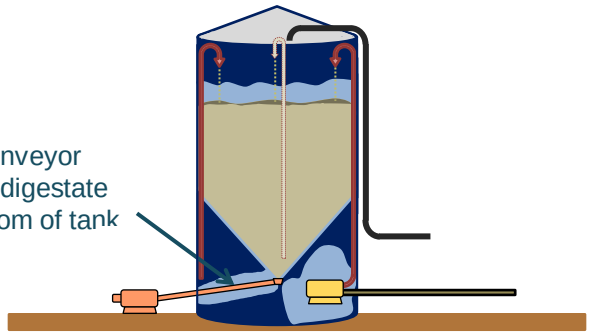



## AD Systems – Vertical Plug Flow

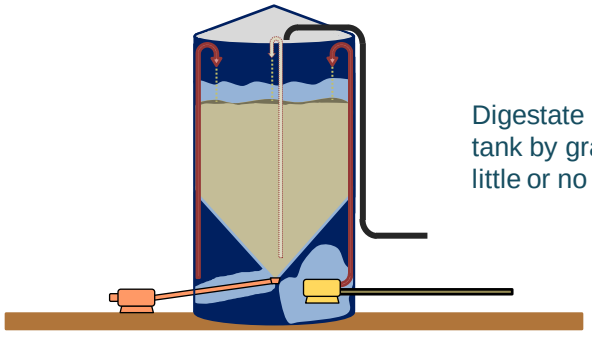


## AD Systems – Vertical Plug Flow

Screw conveyor removes digestate from bottom of tank

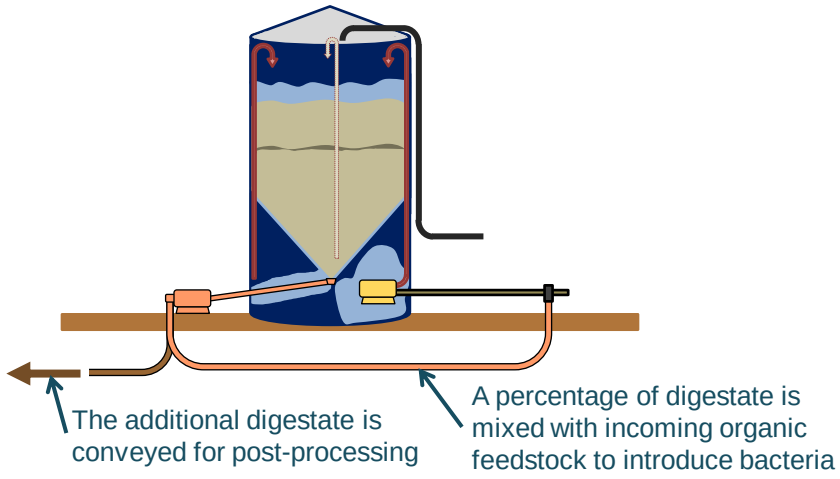


## AD Systems – Vertical Plug Flow



Digestate moves through tank by gravity. There is little or no mixing.

## AD Systems – Vertical Plug Flow




## AD Systems – Plug Flow

Compared to Wet Systems

1. Less gas yield: up to 10 mmbtu/ton of VS, depending upon waste stream
2. Less pre-processing
3. Higher level of contaminants acceptable
4. Much wider range of feedstocks – higher diversion
5. Plug Flow technologies can convert soiled paper streams into biogas, increasing yield
6. Smaller footprint, especially for vertical systems

## AD Systems – Plug Flow

Compared to Dry Fermentation Systems

1. Higher biogas yield 7-10 mmbtu/ton of VS
2. Less odor management / upset potential
3. Accepts liquids
4. More pre-processing, including size reduction
5. Fewer contaminants acceptable
6. More automated, higher energy usage
7. Digestate has lower carbon content but valuable for composting or fertilizer

## Organics

# PART V

## Case Studies

## Case Studies

Evaluate criteria previously discussed:

- Similarities
  - Environmental/Regulatory compliance
  - Low energy costs
  - Low landfill disposal costs
- Variables
  - Existing Processing Capability
  - Proximity to markets for digestate
  - Other
- Business objectives

## Case Studies

Case Study 1 (Under Construction):

- Location: Perris (Riverside County), CA
- Existing processing Capability
  - Transfer Station/MRF with space for expansion
  - Collection operation with CNG fueling
- Close to markets for digestate
- Other
  - Owner/operator has
    - Network of Transfer Stations and MRF's
    - Collection contracts in 50 cities
    - 900 collection trucks that will be 100% CNG by 2020

## Case Studies

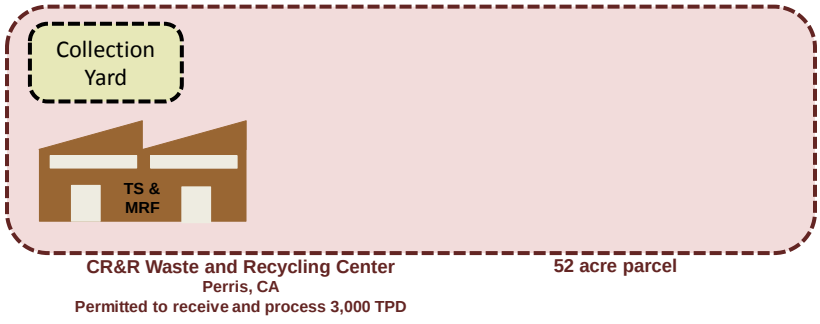
### Case Study 1 (cont'd.):

Business objectives

- Avoid landfill fees for organic materials
- Provide solution for customers' compliance needs
- Reduce greenhouse gas emissions
- Produce RNG for Owner's collection fleet

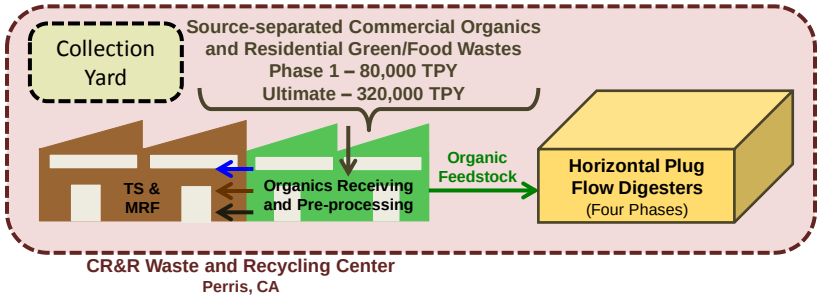
## Case Studies

### Case Study 1 (cont'd.):



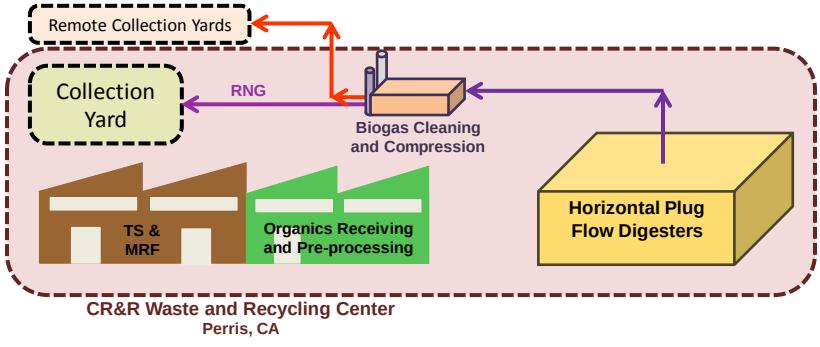
## Case Studies

### Case Study 1 (cont'd.):




## Case Studies

### Case Study 1 (cont'd.):



## Case Studies

### Case Study 2 (Operating Facilities):

- Location: Greater Los Angeles, CA
- Existing processing Capability
  - Mixed-waste MRF
  - WWTP with excess digester capacity and gas-fueled power plant
- Not close to markets for digestate

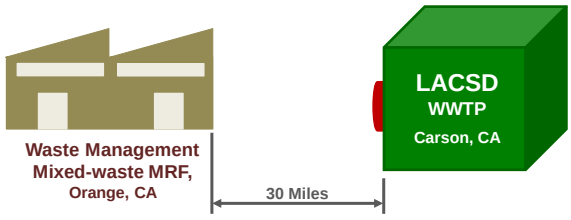
## Case Studies

### Case Study 2 (cont'd.):

- Business objectives
  - Pilot study - driven by strong interest in learning from a pilot program to determine:
    - Economics
    - Technical feasibility
    - Regulatory compliance
  - Satisfy community interest in reduction of environmental impacts

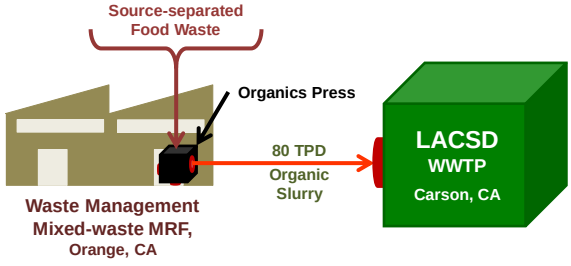
## Case Studies

### Case Study 2 (cont'd.):




## Case Studies

### Case Study 2 (cont'd.):



## Case Studies

### Case Study 3 (Under development):

- Location: San Francisco Bay Area
- Existing processing capability:
  - Transfer Station with space for expansion
  - Single Stream and Clean Commercial MRF
  - Nearby WWTP with excess digester capacity
- Not close to markets for digestate
- Other
  - Long haul with traffic constraints to landfill
  - Weak commodity markets

## Case Studies

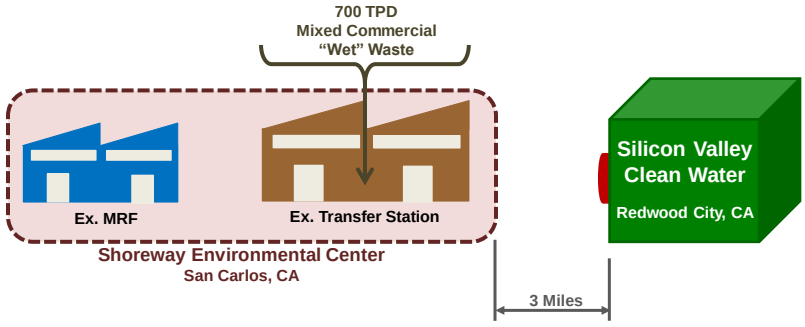
### Case Study 3 (Cont'd.):

Business objectives

- Avoid landfill disposal for organic materials
- Reduce hauling costs and traffic impacts
- Provide solution for customers' compliance needs
- WWTP wants additional biogas
- Satisfy community demands for reduction of environmental impacts

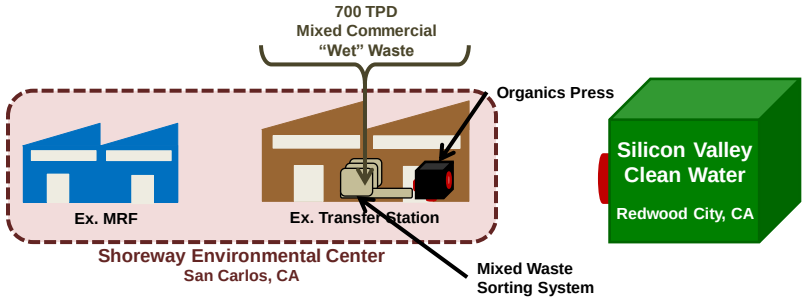
## Case Studies

### Case Study 3 (cont'd.)



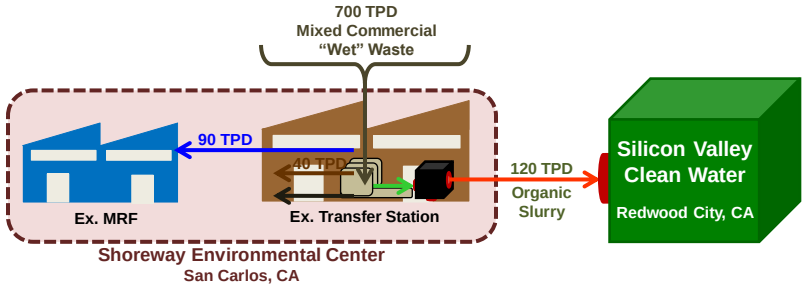

## Case Studies

### Case Study 3 (cont'd.)



## Case Studies

### Case Study 3 (cont'd.)




## Case Studies

### Case Study 4 (Current / In Planning):

- Location: Monterey, CA
- Existing processing capability
  - Operating landfill with gas power plant
  - Mixed-waste MRF being upgraded
  - Dry fermentation AD system
  - Composting yard
  - Adjacent WWTP.
- Close to markets for digestate
- Other
  - Collection operations with CNG fueling
  - Compost yard requires new storm water management system

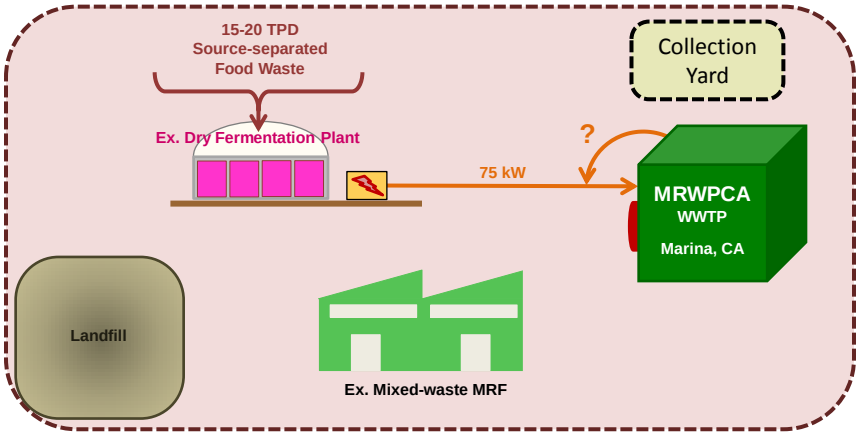
## Case Studies

### Case Study 4 (Cont'd.):

- Business objectives
  - Diversification of revenue stream from sales of RNG and electricity
  - Provide solution for customers' compliance needs
  - Reduce greenhouse gas emissions
  - Develop organics processing capability consistent with expectations of their community and their history of leadership

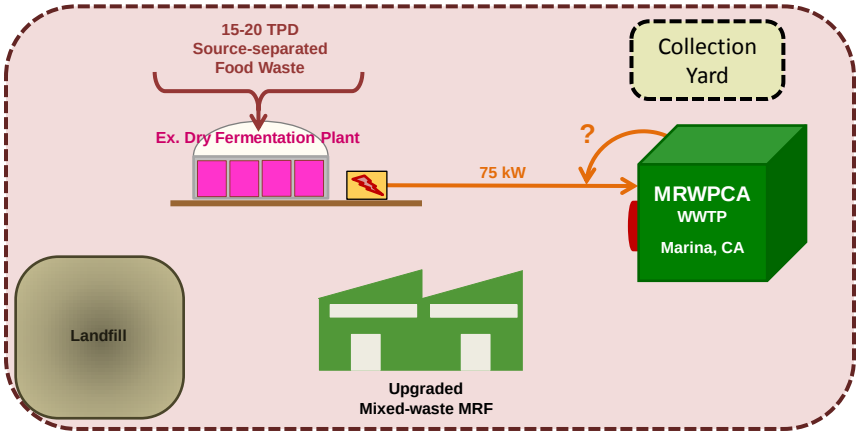
## Case Studies

### Case Study 4 (cont'd.)



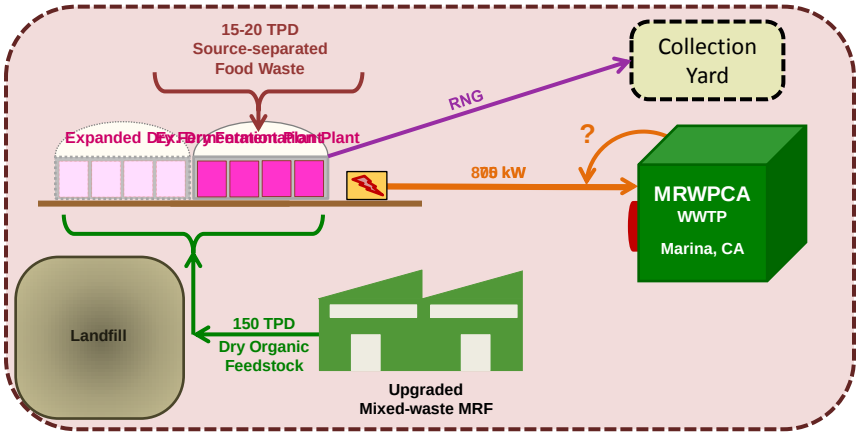
## Case Studies

### Case Study 4 (cont'd.)



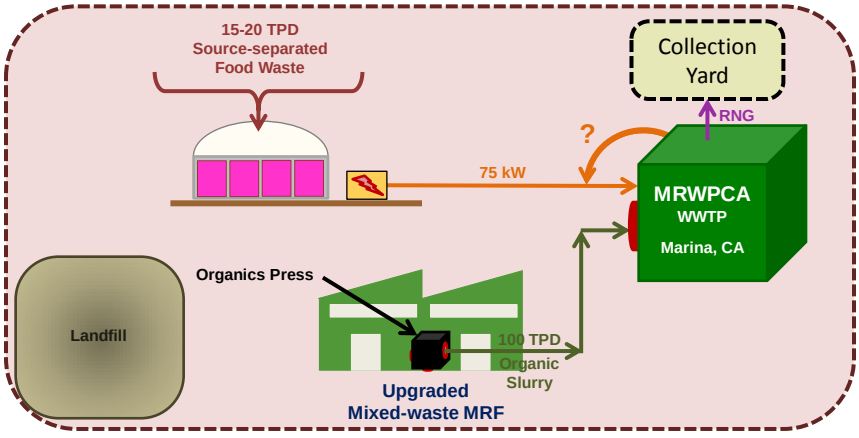

## Case Studies

### Case Study 4 (cont'd.) – Option 1:



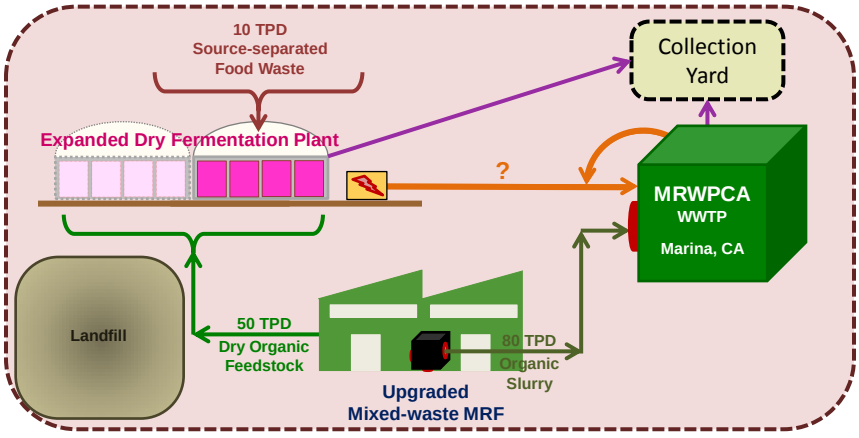
## Case Studies

### Case Study 4 (cont'd.) – Option 2:




## Case Studies

### Case Study 4 (cont'd.) – Option 3:



## Case Studies

Review

- Four different situations:
  - Many similarities
  - Enough variables to require four different approaches
- Key factors:
  - Existing infrastructure
  - Presence of WWTP
  - Proximity to markets for digestate

## Summary of Presentation

- Regulatory influencers
- Waste stream considerations
- AD systems
- Selection criteria
- Presented actual case studies


Energy from Organic Wastes
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